REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
13675.2-EX		

4. TITLE (and Subtitle)	5. TYPE OF REPORT & PERIOD COVERED
Development of Partial Channel Flow for Arbitrary Input Velocity Distributions Using Boundary-Fitted Coordinate Systems	Final Report 15 Feb 76 — 14 Feb 79
	6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)	8. CONTRACT OR GRANT NUMBER(s)
Leslie R. Hester Joe F. Thompson	DAAG29-76-G-0144

9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
Mississippi State University Mississippi State, Mississippi 39762	

11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE
U. S. Army Research Office P. O. Box 12211 Research Triangle Park, NC 27709	Apr 79
	13. NUMBER OF PAGES
	3

14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report)
	Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

DDC RECEIVED APR 19 1979 D

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

The view, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

channel flow
velocity distribution
partial channel flow
computational mechanics

internal flow problems
laminar incompressible flow
symmetrical flow

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report summarizes the results of the attempted solution of the class of problems associated with partial channel flows using a numerical technique of boundary-fitted coordinate systems.

DD FORM 1473 EDITION OF 1 NOV 65 IS OBSOLETE

FINAL REPORT

TITLE: Development of Partial Channel Flow for Arbitrary Input Velocity Distributions Using Boundary-Fitted Coordinate Systems.

GRANT NO.: DAAG29-76-G-0144

PUBLICATIONS: "Development of Partial Channel Flow for Arbitrary Input Velocity Distributions Using Boundary-Fitted Coordinate Systems," D. Kumar, L. R. Hester, and J. F. Thompson, presented at the ASME Symposium on Non-Steady Fluid Dynamics at the ASME Annual Winter Meeting, San Francisco, California, December 10-15, 1978, and published in the ASME Symposium on Non-Steady Fluid Dynamics, BK No. H00718, Pages 53-61, December 1978.
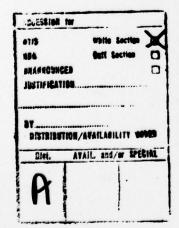
"Recent Developments in the Use of Boundary-Fitted Coordinate Systems for Computational Mechanics," Joe F. Thompson, Z. U. A. Warsi, C. W. Mastin, and L. R. Hester, Eighth U.S. National Congress of Applied Mechanics, Los Angeles, 1978.

SCIENTIFIC PERSONNEL
AND ADVANCED DEGREES:

Leslie R. Hester, Principal Investigator; Joe F. Thompson, Project Director; Dilip Kumar, Graduate Student, awarded the Ph.D. degree December 22, 1978.

STATEMENT OF PROBLEM STUDIED:

The main thrust of the work under this grant was to attempt a solution of the class of problems associated with partial channel flows using a numerical technique of boundary-fitted coordinate systems. Emphasis was placed on those partial channel configurations that are common to laminar flow fluidic devices. Partial channel flows are a special class of internal flow problems in which the main stream of fluid only partially fills the main channel. Additionally, there exists intersecting channels with in and out flows which interact with the main stream flow. Thus it is impossible to obtain an analytical solution because of a mixture of forward and reverse flows associated with the main channel flow and the interaction between the main channel flow and the intersecting channels flow.

79 04 16 077

The study was limited to two-dimensional configurations
with laminar incompressible flow. The final con-
figuration chosen for this study was a fluidic laminar
proportional amplifier that had recently been under
experimental study by separate investigators.

SUMMARY OF MOST IMPORTANT RESULTS:

At the beginning of this study the numerical
technique of boundary-fitted coordinate systems had
been applied only to external flows. For these flows
most of the coordinate systems generated have transformed
planes that consists of a single rectangle. Thus the
initial effort here had to be directed toward generating
coordinate systems for the somewhat more complicated
internal shapes associated with partial channel flows.
It is possible for these configurations to have trans-
formed planes consisting of a single rectangle, however,
it was found that having the transformed plane consisting
of several rectangles and slits would be more advantageous.
From this it became apparent that a general purpose
computer code could be developed that would generate
coordinate systems on which a wide range of internal
flow problems could be solved. This again demonstrated
the versatility of the boundary-fitted coordinate
system.

Thus the first important result of this study was
the development of a general purpose computer code that
would generate coordinate systems on which a wide range
of internal flow problems could be solved. The program
will handle internal flow configurations from a single
straight channel to a channel that consists of:
a main channel; an input nozzle to the main channel;
one control port channel on each side of the main
channel; two vent channels on each side of the main
channel; and two output channels from the main channel.
The configuration can be symmetrical or asymmetrical
with straight or curved walls.

Conservative and non-conservative formulations of
the time-dependent, two-dimensional compressible Navier-
Stokes equations in the primitive variables u, v, and p
were derived in the transformed plane. The Poisson
equation for pressure, an equation for pressure on solid
walls and boundary conditions to evaluate pressure on
entrances and exit of flow sections were also derived
in the transformed plane. The transformed equations
were derived in numerical form using backward time
central space differencing.

79 04 16 077

The second important result of this study was the development of a computer program that yielded the numerical solution of the time-dependent, two-dimensional incompressible Navier-Stokes equations for several partial channel configurations with various boundary conditions. The initial solutions developed were for simple full channels for which good empirical results were known for verification of the numerical program. This being established, partial channel configurations with various entrance and exit boundary conditions were then considered.

Field solutions for the velocity and pressure were obtained for the symmetrical flow case of the most complicated partial channel configuration studied. This configuration consisted of: a main channel flow; an input nozzle flow; two control ports flow; four vent ports flow; and two output ports flow. Good agreement with available experimental data was obtained. Numerical results for the corresponding asymmetrical flow case showed only partial agreement with experimental results.

The number of computational field points used for the most complicated partial channel configuration was approximately 10,000 which required a large amount of computer time for the solution. Part of the dis-agreement with experimental results in the asymmetrical flow case can be placed on the need for more field points, in particular, in the solid boundary corner regions and the interacting flow regions.

Thus it would seem desirable at this point to concentrate further basic research into methods that would decrease the computer time necessary to obtain flow solutions for the asymmetrical flow in partial channel configurations.